Photoemission Spectromicroscopy Study on Passivation of GaAs(100) by CH_3CSNH_2/NH_4OH

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INTRODUCTION

The development of conventional III-V semiconductor device is directly related to their surface properties [1,2]. To obtain high quality surface, surface treatment is critical in device fabrication. Usually surface oxides and contaminations on semiconductors like GaAs and InP can be removed by a wet process, followed by postannealing of passivated samples to eliminate the surface defects and adjust the position of Fermi level at midgap[1-8]. However, because the wet process involes many parameters such as concentration, temperature and pH value of solution, the chemical states and electronic structure of the passivated GaAs and InP have shown discrepancies among different research groups, In this study, we report our investigation of the chemical states and electronic structure of passivated GaAs (100) surface at two different pH values and concentration of CH_3CSNH_2/NH_4OH solution.

EXPERIMENTS

The sample used in this study was single crystal GaAs (100) with doping concentration of $1x10^{18}/cm^2$. It was first cleaned in acetone by ultrasonic bath for 5 min, then dipped into buffer solution of phthalate (PH≈4.01) for 5min to remove native oxides of GaAs(100) surface, and then rinsed with deionized water. Part of wafer was immersed in passivation solution at temperature of 60ºC for 20 min. Then it was dried by blowing nitrogen. The interface of etching and passivation was marked by a line. The chemical states, band bending and morphological information were obtained on two regions with different treatments on MAXIMUM photoemission microscope at BL12.0.1.1 at the Advanced Light Source, Berkeley. The beam spot used in the experiment is about 1 micron. The energy resolution is about 0.6 eV. $S_{L2,3}$ edge of NEAXFES and photoemssion data were also collected at Advanced Material Chamber of BL9.3.2.

RESULTS AND DISCUSSION

After etched by phthalate buffer solution (pH≈4.01) and followed by passivation in the CH_3CSNH_2/NH_4OH solution (pH≈10.0), the sample surface remained smooth and mirror-like, indicating that the process of both etching and passivation are mild. The survey spectra taken from above two different regions are displayed in figure 1. The ratios of Ga to As are 0.53 and 0.48 for the etched region and passivated region, respectively. (The calculated value is only area ratio of Ga to As, the data were collected under the same condition) The different ratios of Ga to As at different regions are due to different reactivity and solubility in acid and alkaline solution. A residual of F2s level was observed at kinetic energy of 94.0eV for the phthalate buffer etched GaAs (100) surface, and disappeared completely after passivation.

Photoemission spectra of As3d in bulk GaAs(100) were observed for two different regions (marked as line A) as shown in figure 2. The lower kinetic energy side (marked as line B) increased remarkably for passivation region, indicating that As sulfide in As_2S_3 component was formed on passivated surface region. Line C is from residual of arsenic oxides by buffer solution

etchant. the line shape and symmetry of Ga3d spectra are different from both etching and passivation regions, a shift of 1.2eV at lower kinetic energy was thought to be from the residual of gallium oxides for etched surface; the increase of lower kinetic energy shoulder can be attributed to the formation of Ga sulfides because of the reaction at the interface between GaAs wafer and solution. Comparing the two different regions, the position of Fermi level has a shift of 0.5eV toward conduction band minimum (CBM), which indicates a decrease of the surface defects for freshly passivated surface. The passivated wafer in lower concentration and pH value of 9.0 were collected at beamline 9.3.2 in ALS, indicating formation of the same sulfide compositions on the surface, but the ratio of Ga to As is changed with concentration and pH value.

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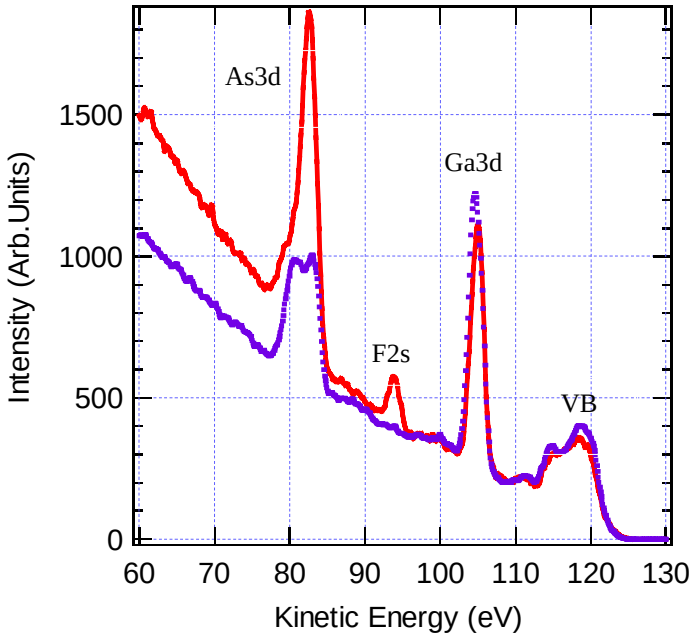

Fig.1 The survey spectra of the etched and the passivated regions of the GaAs(100) Surface, the line indicating the etched region and the dots indicating the passivated region. Photo Energy is 130eV.

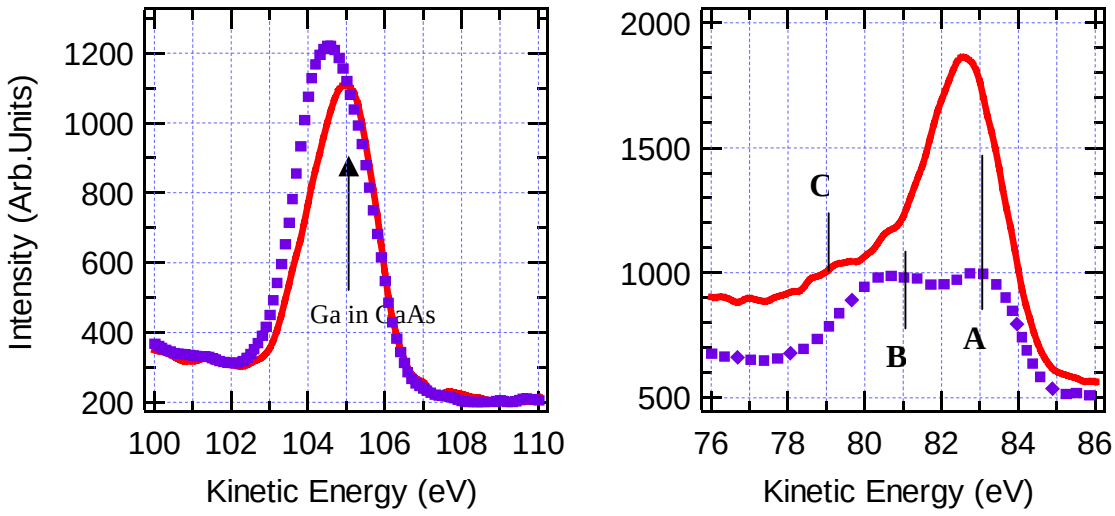

Fig.2 The Ga3d and As3d spectra of the etched and the passivated regions of the GaAs(100) surface, the line indicating the etched region and the dots indicating the passivated region. Photo Energy is 130eV.